Our Ref.: 42390.P4264

APPLICATION FOR UNITED STATES LETTERS PATENT

FOR

Ensuring Quality Of Service (QOS) For A Multi-Media Call Through Call Associated Individual Media Stream Bandwidth Control

Inventor(s): **Rajendra S. Yavatkar**
James E. Toga

Prepared by:

BLAKELY SOKOLOFF TAYLOR & ZAFMAN, LLP
12400 Wilshire Boulevard, 7th Floor
Los Angeles, California 90025
(503) 684-6200

Ensuring Quality Of Service (QOS) For A Multi-Media Calls Through Call Associated Individual Media Stream Bandwidth Control

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the field of multi-media calls. More specifically, the present invention relates to the quality of service of multi-media calls.

2. Background Information

As advances in microprocessor and other related technologies continue to improve the price/performance of various electronic components, multi-media calls, such as video conferencing calls, including those calls conducted using personal computers (PC), have become increasingly popular in recent years. Numerous PC based multi-media call products designed to take advantage of the increased processing power of today's PCs are now available in the market place. An example of such multi-media call products is the ProShare™ Video Conferencing product, available from Intel Corp., of Santa Clara, CA., the assignee of the present invention.

At the same time, with the advances in networking technology, increasing number of computers are connected to one another via private and public networks, such as the Internet, resulting in increasing number of multi-media calls

being conducted over the various networks. Many of these networks, such as the Internet, are packet based and "best effort" type of networks. That is, end to end delivery for a packet can take any arbitrary amount of time, and there is no guarantee that the delivery time will be smaller than the latency requirement. Since the media packets of multi-media are isochronous in nature, as a result, the quality of service (QOS) for these multi-media calls cannot be guaranteed.

Recommendation H.323 of the International Telecommunication Union – Technical Section (ITU-T), entitled "Packet Based Multi-Media Communication System", published 11/96, provides for call level admission control into a local area network (LAN) that allows a call to be denied access into the LAN due to its bandwidth limitation. The provision prevents the LAN from being overloaded, and partially addresses the QOS issue. However, potential bandwidth limitations of the intermediate hops remain a problem. Furthermore, merely managing a LAN's bandwidth at the call level often results in waste, as there is no correlation to the actual bandwidth consumption by the media streams of the calls. Notwithstanding these shortcomings, for interoperability reason, increasing number of multi-media call products have implemented support for H.323. Thus, a more efficient and/or effective approach to guaranteeing the QOS of a multi-media call that is compatible with the H.323 recommendation is desired.

SUMMARY OF THE INVENTION

A multi-media call application is disclosed. The application guarantees quality of service (QOS) for a packet based multi-media call (CALL). The guaranty is effectuated through call associated individual media stream bandwidth control.

BRIEF DESCRIPTION OF DRAWINGS

The present invention will be described by way of exemplary embodiments, but not limitations, illustrated in the accompanying drawings in which like references denote similar elements, and in which:

Figure 1 illustrates an exemplary network suitable for practicing the present invention;

Figure 2 is a block diagram illustrating one embodiment of the method of the present invention; and

Figures 3a-3g are block diagrams illustrating one embodiment each of various bandwidth reservation related messages of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

In the following description, various aspects of the present invention will be described. Those skilled in the art will also appreciate that the present invention may be practiced with only some or all aspects of the present invention. For purposes of explanation, specific numbers, materials and configurations are set forth in order to provide a thorough understanding of the present invention. However, it will also be apparent to one skilled in the art that the present invention may be practiced without the specific details. In other instances, well known features are omitted or simplified in order not to obscure the present invention.

Parts of the description will be presented in terms of operations performed by a computer system, using terms such as data, flags, bits, values, characters, strings, numbers and the like, consistent with the manner commonly employed by those skilled in the art to convey the substance of their work to others skilled in the art. As well understood by those skilled in the art, these quantities take the form of electrical, magnetic, or optical signals capable of being stored, transferred, combined, and otherwise manipulated through mechanical and electrical components of the computer system; and the term computer system include general purpose as well as special purpose data processing machines, systems, and the like, that are standalone, adjunct or embedded.

Various operations will be described as multiple discrete steps in turn in a manner that is most helpful in understanding the present invention, however, the order of description should not be construed as to imply that these operations are necessarily order dependent, in particular, the order of presentation.

Referring now to **Figure 1**, wherein a block diagram illustrating an exemplary network suitable for practicing the present invention. As illustrated, exemplary network **100** includes client computer **102**, sub-net bandwidth manager **104** and router **108** coupled to each other through medium **110**. Additionally, for the illustrated embodiment, exemplary network **100** includes gatekeeper **106** and gateway **107** coupled to each other and the earlier enumerated elements as shown.

Medium **110** facilitates communication between the coupled elements. For the illustrated embodiment, communication is conducted on a packet basis. The packet based communication may be conducted using any one of a number of protocols known in the art. Medium **110** may be any networking medium and signaling scheme suitable for such packet based communication. An example is the twisted pair medium with electrical signals propagated in accordance with IEEE's 802.3 standard, titled Local Area Network (LAN): Carrier Sense Multiple Access With Collision Detection CSMA/CD (commonly known as Ethernet), published 1985.

Router **108** facilitates internetworking communication between client computer **102**, SBM **104**, and so forth, with members of other networks. Router **108** is intended to represent a broad category of such elements known in the art, including like elements such as switches, bridges, and so forth.

SBM **104** manages bandwidth of network **100**. SBM **104** controls admission of traffic into network **100**, including admission by traffic class and reservation of bandwidth for the admitted traffic class. Additionally, SBM **104** in cooperation with other SBMs of other interconnected network enable end-to-end

bandwidth reservation on all intermediate hops, from one end to another end of a traffic flow. In one embodiment, SBM **104** manages bandwidth of network **100** and cooperates with other SBMs in accordance with SBM (Subnet Bandwidth Manager): A Protocol for RSVP-based Admission Control over IEEE 802-style networks, draft IETF-ISSL-IS802-SBM-06.TXT, published March, 1998. SBM **104** may be implemented using any one of the servers known in the art. An example of such servers is a Pentium® II processor based server, such as the PowerEdge server available from Dell Computer of Texas. Pentium is a registered trademark of Intel Corp., assignee of the present invention. SBM **104** may also be implemented as a switch or router, such as element **108** described earlier.

Client computer **102** is equipped to enable a user to conduct a packet based multi-media call with a counterpart located at another end point over one or more interconnected networks. Client computer **102** includes in particular multi-media call application **112** and bandwidth reservation service **114**. Multi-media call application **112** provides the user with the ability to conduct the multi-media call. Multi-media application **112** conducts the multi-media call using multiple media streams, sending and receiving each media stream over individualized logical channel. For the illustrated embodiment, multi-media application **112** is a video conferencing application that enables the user to conduct video conference calls. The video conferencing application conducts the video conference calls in accordance with ITU-T's H.323 recommendation, using multiple audio and video streams sent and received over individualized logical channels. Additionally, in accordance with the present invention, multi-media application **112** in cooperation with bandwidth reservation service **114** ensure quality of service (QOS) of the multi-media call using call associated individual media stream bandwidth control, to be

described more fully below. Except for the teachings of the present invention incorporated in multi-media call application **112** and bandwidth reservation service **114**, client computer **102** including multi-media application **112** and bandwidth reservation service **114** are intended to represent a broad category of these elements known in the art. An example of client computer **102** is a Pentium® II processor based multi-media computer, such as the Dimension PCs available from Dell Computer. An example of multi-media call application **112** is earlier described ProShare® Video Conferencing product, available from Intel Corp. An example of bandwidth reservation service **114** is the PC RSVP product, also available from Intel Corp. In an alternate embodiment, bandwidth reservation service **114**, including the incorporated teachings of the present invention, is an integral part of the operating system of client computer **102**. Examples of such operating system that can include bandwidth reservation service **114** include the Windows® family of operating systems, e.g. Windows® 95, Windows® NT and so forth.

Gatekeeper **106**, for the illustrated embodiment, facilitates call level admission control into network **100** for H.323 compliant multi-media calls between end points coupled to network **100**, such as client computer **102**, and end points outside network **100**. Gateway **107** provides real-time, two-way communications between the above described end-points including but not limited to translation of transmission formats. Both gatekeeper **106** and gateway **107** facilitate the call level admission control and real time communication respectively in accordance with ITU-T's H.323 recommendation. Gatekeeper **106** as well as gateway **107** may also be implemented using one or more of a number of servers known in the art.

Referring now also to **Figure 2**, wherein one embodiment of the method step of the present invention is shown. As illustrated, to ensure the QOS of the multi-media call, multi-media call application **112** first reserves bandwidth for the multi-media call through SBM **104** while establishing a connection for the multi-media call, steps **202-208**. In alternate embodiments, the call level bandwidth reservation may be made independent of establishing a connection for the multi-media call. Multi-media application **112** then subsequently causes SBM **104** to allocate the reserved call level bandwidth to individual media streams of the multi-media call while establishing logical channels for the individual media streams during the multi-media call, step **212**. In alternate embodiments, the allocation of the reserved call level bandwidth to individual media streams may be caused independent of establishing logical channels for the individual media streams. At call termination, multi-media call application **112** notifies SBM **104** of the termination of the call to release the call level bandwidth reservation, while tearing down the connection for the multi-media call, step **214**.

For the illustrated embodiment, at steps **202-208**, multi-media application **112** first determines whether gatekeeper **106** is present in network **100**, step **202**. If gatekeeper **106** is present, multi-media application **112** registers the multi-call call with gatekeeper **106**, in a manner that causes gatekeeper **106** to determine whether to admit the multi-media call into network **100** without taking into consideration the multi-media call's bandwidth requirement, step **204**. The discovery of gatekeeper **106** may be accomplished through any one of a number of known methods, including but not limited to referencing a statically stored value and address of its controlling gatekeeper at a predetermined location, or issuing queries on network **100** to solicit response from gatekeeper **106**. In one embodiment, the

required manner of registration is accomplished by registering the multi-media call with gatekeeper **106** and requesting gatekeeper **106** to set aside zero bandwidth for the multi-media call. This conditional registration enables the present invention to be practiced for H.323 compliant multi-media calls, especially when a H.323 compliant gatekeeper is present in the network to which client computer **102** is attached.

Upon either determining that gatekeeper **106** is not present in network **100** or registering the multi-media call with gatekeeper **106** in the required manner, multi-media application **112** determines if SBM **102** is present in network **100**, step **206**. If SBM **102** is not present, multi-media application **112** continues the call as in the prior art, i.e. with QOS guaranty for the multi-media call, step **208**. On the other hand, if SBM **102** is present, multi-media application **112** registers the call with SBM **102** and requesting SBM **102** to reserve bandwidth for the multi-media call, step **210**. In response, if sufficient bandwidth exists in network **100**, SBM **102** admits the multi-media call and reserves the requested bandwidth in network **100**. If insufficient bandwidth exists in network **100**, SBM **104** rejects the request. In one embodiment, the bandwidth reservation is accomplished by SBM **104** in accordance with the above described SBM protocol, with new messages defined in accordance with the present invention, to be described more fully below. In one embodiment, if the call level bandwidth reservation with SBM **104** is rejected, multi-media application **112** continues the multi-media call without QOS guaranty, step **208**. In an alternate embodiment, multi-media application **112** terminates the multi-media call for insufficient network resources.

At step **212**, while establishing a logical channel for the media stream, if the multi-media call was admitted by SBM **104**, multi-media call application **112** calls bandwidth reservation service **114** to request SBM **104** to allocate a portion of the call level bandwidth reservation for a media stream. Multi-media call application **112** provides call level information to bandwidth reservation service **114** for inclusion in the request, such that SBM **104** can associate the media stream with the appropriate call level bandwidth reservation. The call level information include call type, e.g. H.323, call ID, and endpoint ID. Endpoint ID includes information such as Internet Protocol (IP) address, protocol ID and port number. The request to bandwidth reservation service **114** may be made in any one of a number of known inter-program communication techniques. In alternate embodiments, multi-media call application **112** may perform this request itself. However, in a bandwidth managed network, it is likely such bandwidth reservation service will be provided by either a utility or as an integral part of the operating system, as more than one application will likely want to leverage on the fact that the network bandwidth is being managed. Thus, it is more efficient to effectuate the desired allocation by invoking the common service.

In response, bandwidth reservation service **114** requests SBM **104** to allocate a portion of the call level bandwidth reservation to the media stream, including the call level information in the request to enable SBM **104** to associate the media stream with the appropriate call level bandwidth reservation. In the above described embodiment where bandwidth reservation service **114** is implemented using PC-RSVP, communications between PC-RSVP and SBM **104** are conducted using conventional RSVP messages. In turn, SBM **104** makes the allocation accordingly in network **100**, as well as requests networking equipment of the

intermediate hops to do so through SBMs of the interconnected networks of the intermediate hops. As a result, QOS of the multi-media call can be ensured. For the illustrated embodiment, communications between SBM **104** and SBMs of the interconnected networks of the intermediate hops are conducted using messages and protocol in accordance with the above described SBM protocol.

In one embodiment, SBM **104** also provides feedback to multi-media application **112** through bandwidth reservation service **114** if it fails to establish end-to-end bandwidth reservation for an individual media stream. In response, multi-media application **112** adjusts the operating parameters of the multi-media call to ensure the user continues to perceive performance commensurate with QOS guaranteed, e.g. temporarily slowing down video refresh rate, or switching to periodic still images as opposed to live video and so forth. In one embodiment, multi-media call application **112** may also adjust the call level bandwidth reservation with SBM **104** during the multi-media call. In one embodiment, the call level reservation is treated by SBM **104** as a "soft" reservation. If the reserved bandwidth is not being used for a predetermined period, e.g. multi-media application **112** fails to cause the reserved bandwidth to be allocated to individual media streams within the time period, SBM **104** releases the reservation.

Figure 3a illustrates one embodiment of a discovery packet for use by multi-media application **112** to discover the presence of SBM **104** in network **100**. For the illustrated embodiment, discovery packet **302** includes common header **301** (to be described more fully below) and client computer's IP address **304**. In one embodiment, discovery packet **302** is sent to a predetermined IP multi-cast address and a predetermined User Datagram Protocol (UDP) port number with the

"IP_MULTICAST_TTL" value set to 1. **Figure 3b** illustrates one embodiment of a response packet for use by SBM **104** to respond to the multi-media call application's discovery packet. For the illustrated embodiment, response packet **312** includes common header **301**, SBM's IP address **314**, and a UDP port number **316** at which SBM **104** listens for incoming requests.

Figure 3c illustrates one embodiment of a call level bandwidth reservation packet for use by multi-media application **112** to reserve call level bandwidth reservation or subsequently modify the reservation with SBM **104**. For the illustrated embodiment, call level bandwidth reservation/modification packet **322** includes common header **301**, call family identifier **324**, call identifier **326**, endpoint identifier **328** and bandwidth requirement **330**. Call family identifier **324** specifies the call class, e.g. H.323. Call identifier **326** uniquely identifies the multi-media call. End-point identifier **328** uniquely identifies the "requester" of the call level bandwidth, including e.g. IP address and port number of client computer **102** as well as a protocol ID. Bandwidth requirement **330** specifies the call level bandwidth requested, e.g. in bits per second. **Figure 3d** illustrates one embodiment of a call level bandwidth request confirmation packet for use by SBM **104** to respond to the multi-media call application's call level bandwidth reservation/modification packet. For the illustrated embodiment, confirmation packet **332** includes common header **301**, call family identifier **334**, call identifier **336**, endpoint identifier **338**. Call family identifier **334**, call identifier **336**, and end-point identifier **338** have the same meanings as described earlier for call family identifier **324**, call identifier **326**, and end-point identifier **328**.

Figure 3e illustrates one embodiment of a call level bandwidth request rejection packet for use by SBM **104** to respond to the multi-media call application's call level bandwidth reservation/modification packet. For the illustrated embodiment, rejection packet **342** includes common header **301**, call family identifier **344**, call identifier **346**, endpoint identifier **348**, rejection code **349** and bandwidth available **350**. Call family identifier **344**, call identifier **346**, and end-point identifier **348** have the same meanings as like elements described earlier for reservation and confirmation packets **322** and **332**. Rejection code **349** denotes the reason for rejection, and if the reason is for insufficient bandwidth, bandwidth available **350** denotes the amount of bandwidth available for reservation. **Figure 3f** illustrates one embodiment of a call disengage packet for use by multi-media application **112** to notify SBM **104** of the termination of the multi-media call. For the illustrated embodiment, call disengage packet **352** includes common header **301**, call family identifier **354**, call identifier **356** and endpoint identifier **358**, having meanings similar to like elements of the other packets.

Figure 3g illustrates one embodiment of common header **301**. For the illustrated embodiment, common header **301** includes version number **362**, message type **364**, and sequence number **366**. Version number **362** denotes the version level of the protocol. Message type **364** denotes the nature of the message. In one embodiment, "1" denotes a discovery packet, "2" denotes a response packet, "3" denotes a reserve packet, "4" denotes a reserve confirmation packet, "5" denotes a reservation rejection packet, "6" denotes a modify packet, "7" denotes a modify confirmation packet, and "8" denotes a disengage packet. Sequence number **366** is a non-decreasing message number generated by the sender.

While the present invention has been described in terms of the above illustrated embodiments, those skilled in the art will recognize that the invention is not limited to the embodiments described. The present invention can be practiced with modification and alteration within the spirit and scope of the appended claims. In particular, network **100** may have one or more client computers, one or more SBM (by segment), one or more routers, and so forth. The description is thus to be regarded as illustrative instead of restrictive on the present invention.

Thus, a method for ensuring the quality of service for a multi-media conference call using call associated individual media stream bandwidth control has been described.
